

APPENDIX E
WATER RESOURCES

APPENDIX E: WATER RESOURCES

HYDRAULIC AND HYDROLOGIC CALCULATIONS

April 2002

St. Maries River Flood Analysis

Flood Frequency Analysis

Annual peak stream flow data for USGS Stream Flow Gage Station #12414900, located on the St. Maries River near Santa, Idaho, was downloaded from the USGS water resources website for the period 1966-1996 (USGS 2002). These peak stream flow values were fitted to the Log Pearson type III probability distribution function to calculate the stream flow values for the flood recurrence intervals as shown in Tables E1 – E3. The stream flow values were then adjusted by the ratio of the drainage area of the Santa Gage location (275 mi^2) and the project site location (205 mi^2). For example, the estimated 2-year recurrence stream flow value at the project site, 2251 cfs, equals $(205 / 275) \times 3020 \text{ cfs}$. The recorded stream flow values exceeding the 2-yr flood flows are shown in Figure E1.

Table E1: St. Maries River Annual Peak Discharge at Santa, ID (1966-1996)

Date	Peak Discharge (cfs)	Log ₁₀ Discharge	Date	Peak Discharge (cfs)	Log ₁₀ Discharge
1-Apr-66	1480	3.170	21-Feb-82	5960	3.775
12-May-67	1910	3.281	19-Feb-83	3720	3.571
20-Feb-68	4340	3.637	15-Mar-84	2700	3.431
24-Apr-69	3040	3.483	11-Apr-85	3470	3.540
23-Jan-70	3190	3.504	24-Feb-86	2700	3.431
4-May-71	2040	3.310	1-Feb-87	2260	3.354
21-Jan-72	6290	3.799	27-Mar-88	2880	3.459
16-Jan-73	1200	3.079	22-Apr-89	2170	3.336
15-Jan-74	10700	4.029	2-Jun-90	5910	3.772
15-May-75	2850	3.455	20-Feb-91	3100	3.491
10-Apr-76	3010	3.479	21-Feb-92	2600	3.415
9-Apr-77	780	2.892	4-May-93	2670	3.427
14-Dec-77	3440	3.537	4-Mar-94	889	2.949
6-May-79	5510	3.741	20-Feb-95	4350	3.638
26-May-80	1510	3.179	9-Feb-96	12300	4.090
16-Feb-81	4450	3.648			

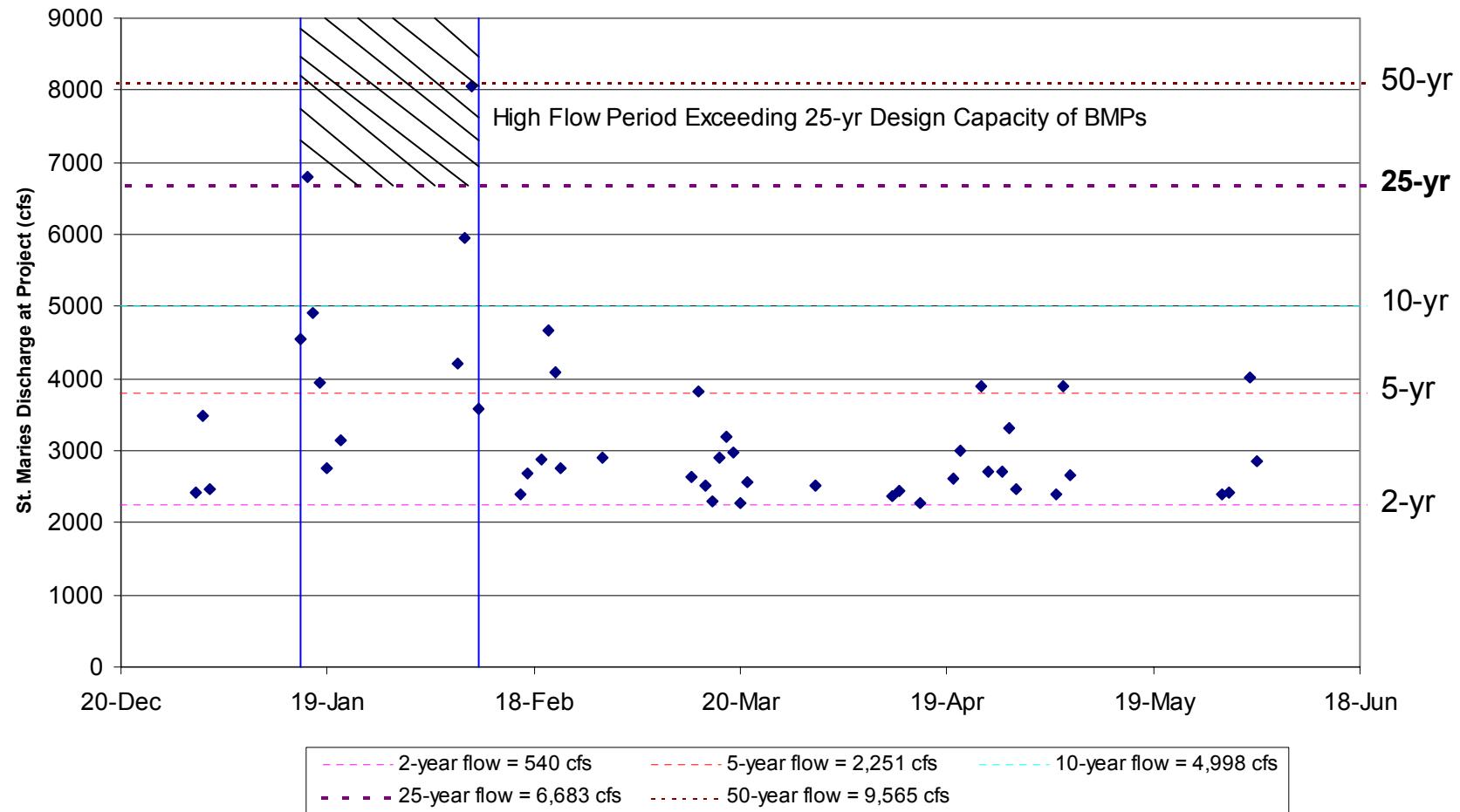
Table E2: Statistical Calculations for Log Pearson III Probability Distribution

Mean	Std. Dev.	Skewness
Log ₁₀	Log ₁₀	Log ₁₀
3.481	0.271	0.017

Table E3: Log Pearson III Calculated Flood Event Stream Flows

	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-Year
Log P III Freq. Factor	-2.291	-0.003	0.838	1.276	1.741	2.049	2.316	2.568
Log ₁₀ Discharge	2.860	3.480	3.708	3.826	3.953	4.036	4.108	4.177
Log P III Flows (cfs)	724	3,020	5,104	6,705	8,965	10,863	12,831	15,019
Site Flows (cfs)	540	2,251	3,805	4,998	6,683	8,098	9,565	11,196

Figure E1. Discharge Occurrences Exceeding 2-Year Flow Event (1966-2000)



Channel Flow Routing using HEC-RAS

The flood event stream flow values for St. Maries River, as shown in Table E3, and two stream cross-section surveys at the project site were entered into the Army Corps of Engineers program “HEC-RAS: River Analysis System” to estimate stream surface elevations. The cross-section locations are shown in Figure E2 and the cross-section profiles are shown in Figures E3 & E4. The cross section survey points were entered into HEC-RAS and modified to include the proposed 18” berms, offset from the right side bank by approximately 30’. The model was used for the original surface elevations and the modified “with berm” surface profile and no significant water surface elevation differences were observed. The Manning’s roughness coefficient, n, was entered for the St. Maries River channel and flood plains as shown in Table E4.

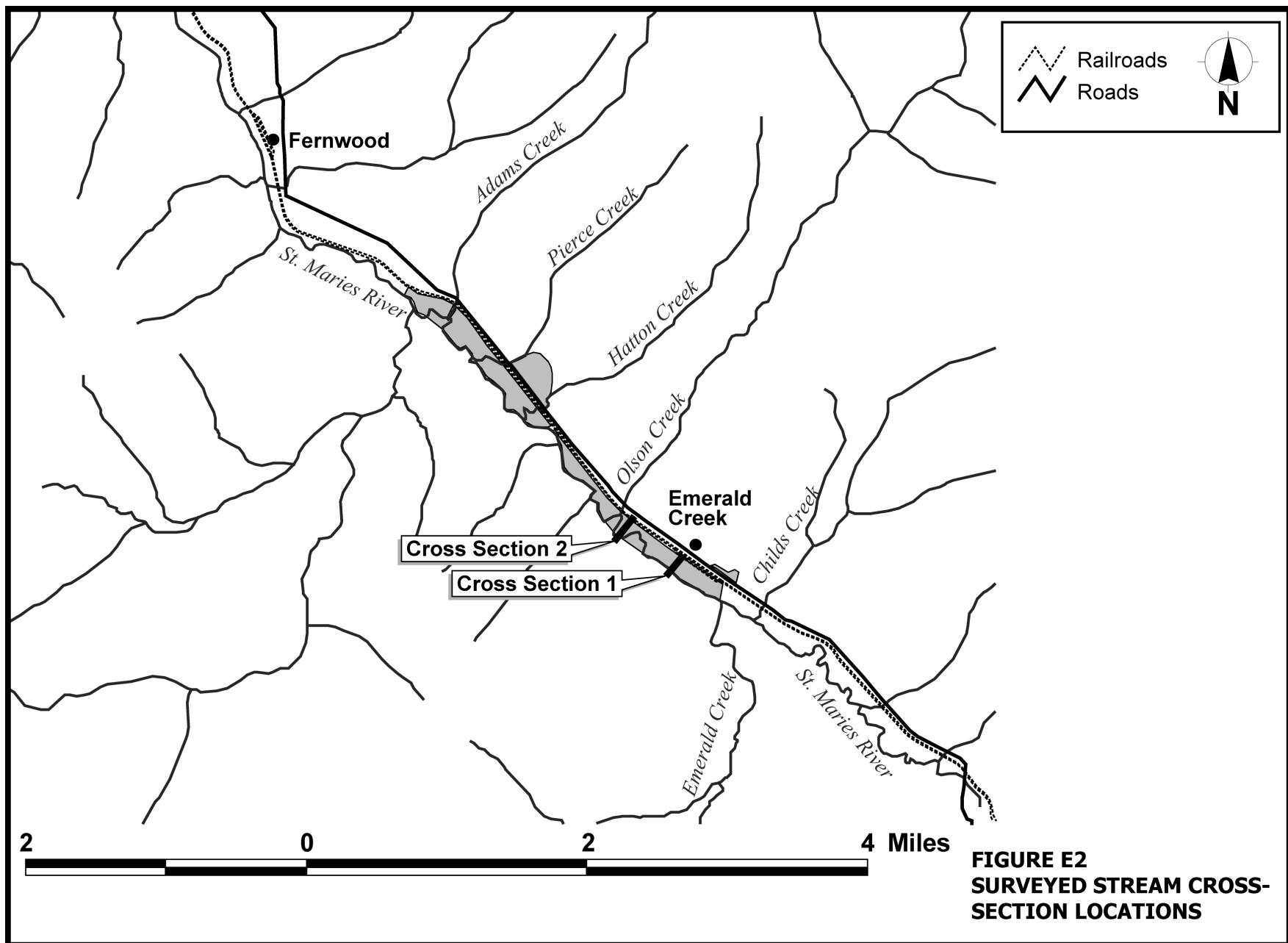
Table E4: Manning’s Roughness Coefficient

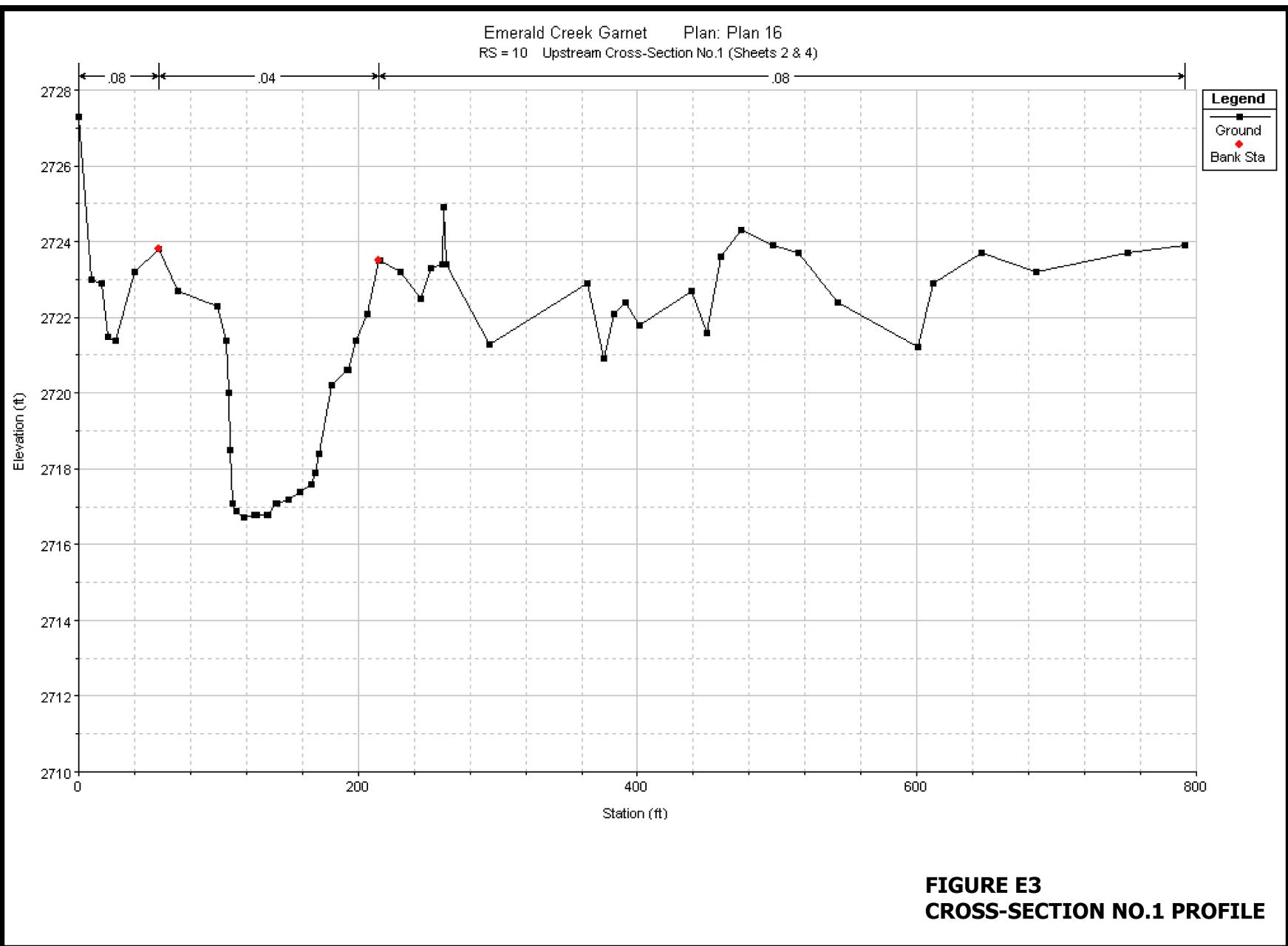
St. Maries River channel	n = 0.04	Minor stream, on plain, clean, winding, some pools & shoals
Project Site Flood Plain	n = 0.08	Flood plain, pasture, high grass

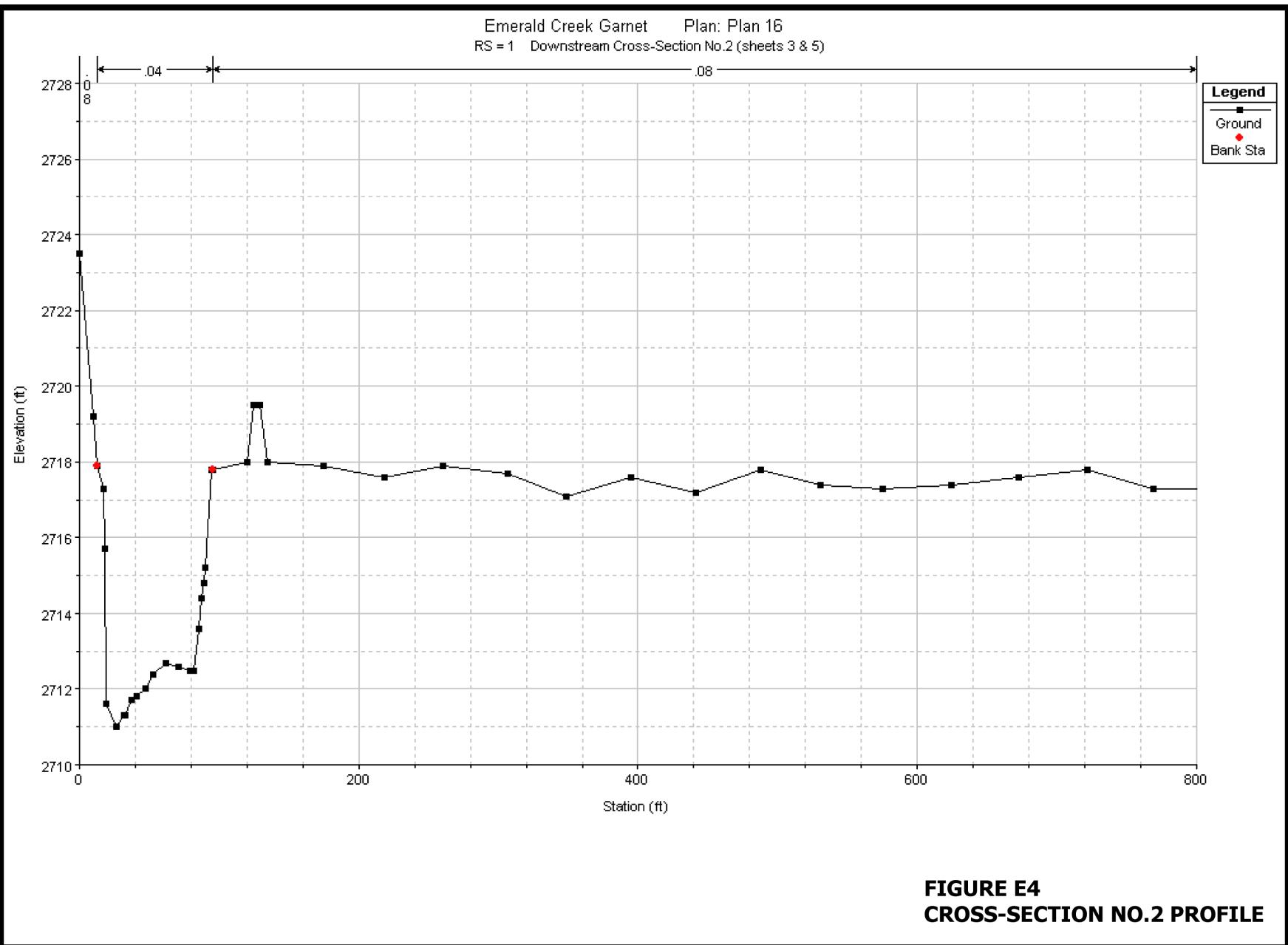
The default contraction/expansion values of 0.1 and 0.3 were used to account for energy losses between the two cross sections. Intermediate cross sections were interpolated along the stream reach between the two surveyed cross sections as shown in Figure E5. A channel slope of 0.0014 ft/ft, estimated from the surveyed channel bottoms, was used to estimate the energy slope to calculate the normal depth (using Manning’s equation). The flood event stream flow values, as shown in Table E3, were entered for steady flow analysis with a subcritical flow regime.

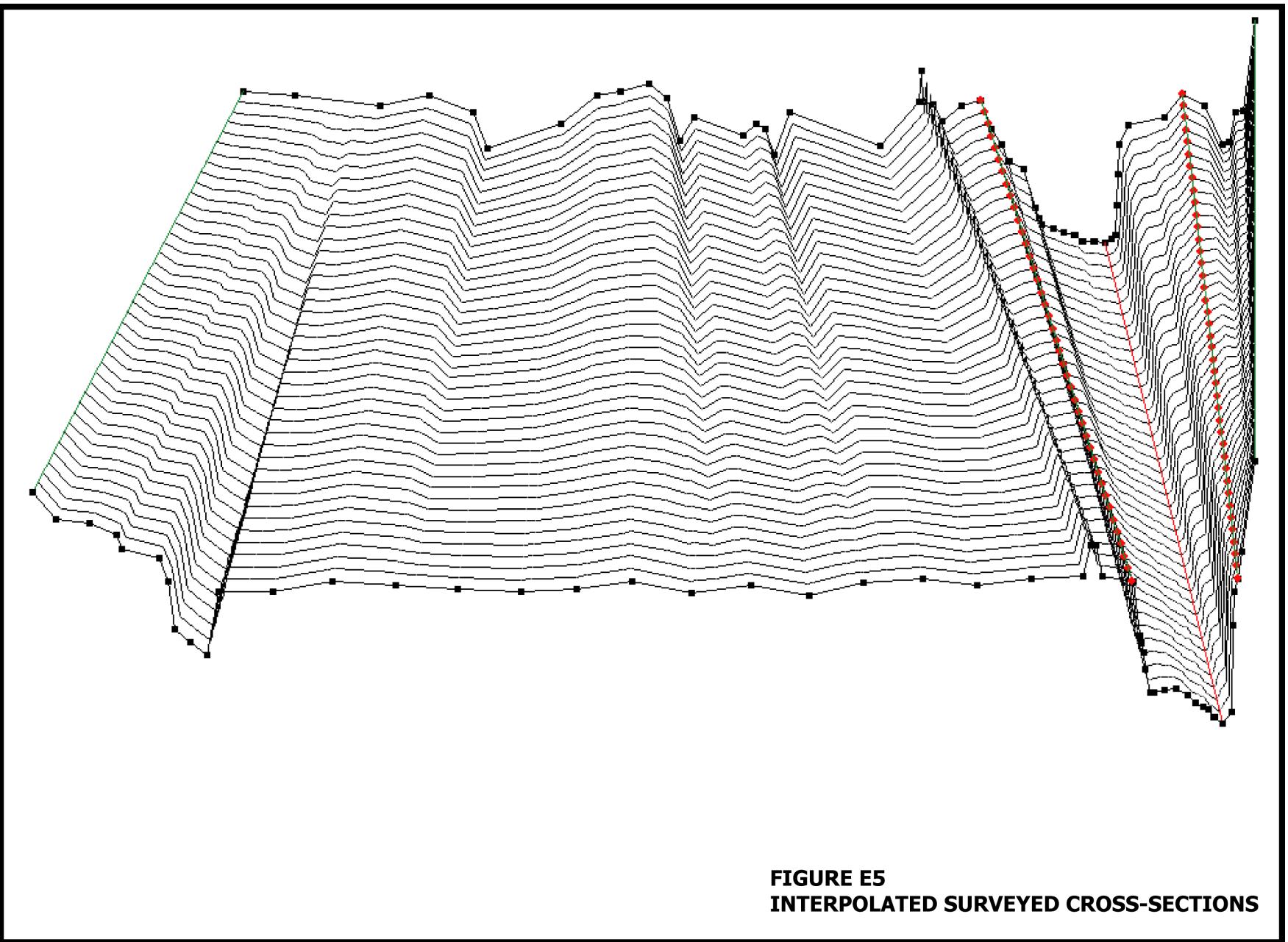
The resulting cross section profiles with water surface elevations indicate the stream overflows it’s banks for 2-year storm events and the 18” berm can be expected to prevent up to the 5-year flood event from entering the floodplain as shown in Figures E6 and E7. The calculated St. Maries River water surface elevation throughout the stream reach is illustrated in Figure E8. The rating curves for cross section No.1 and cross section No.2 are shown in Figures E9 and E10, respectively.

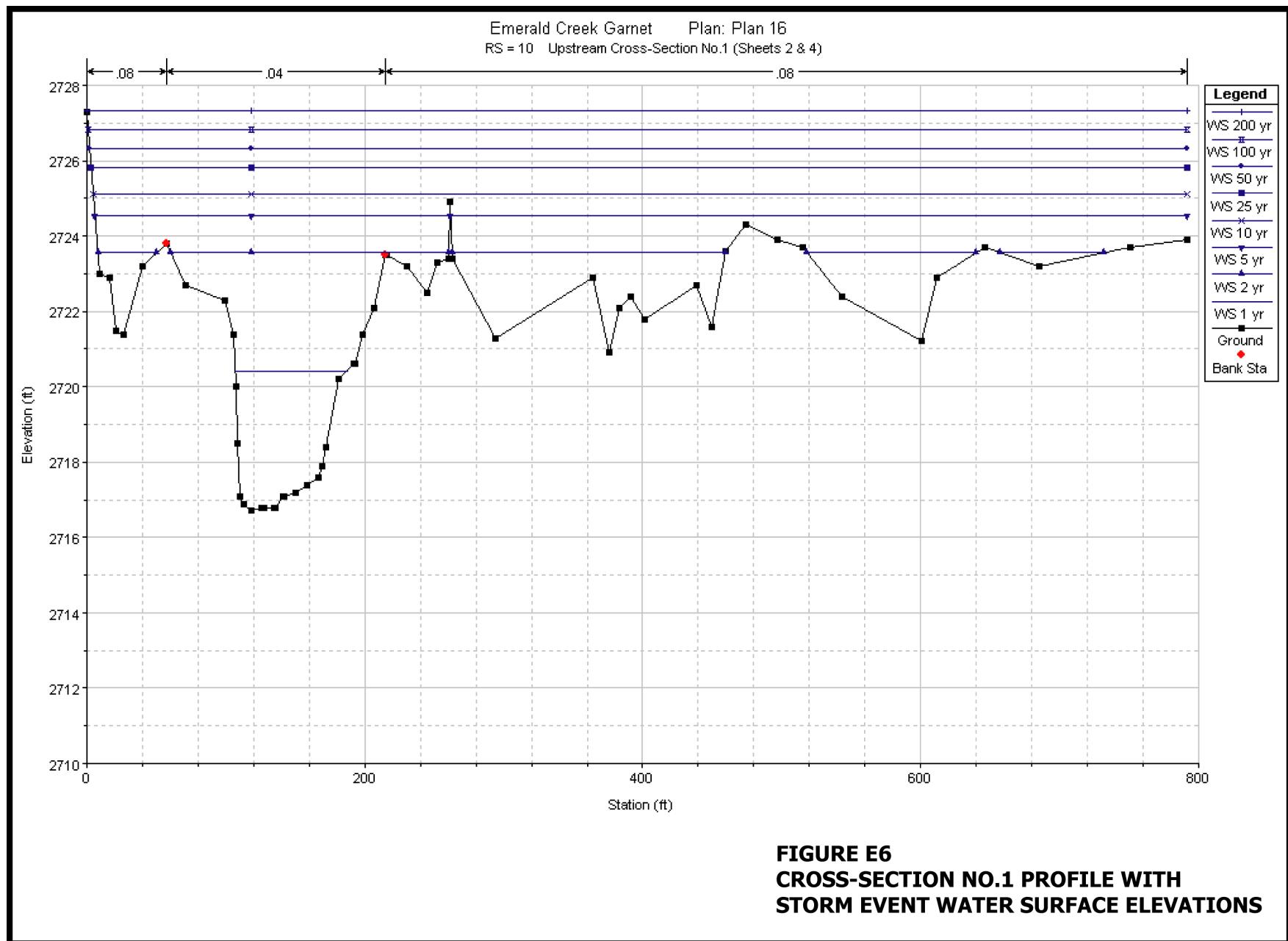
E4

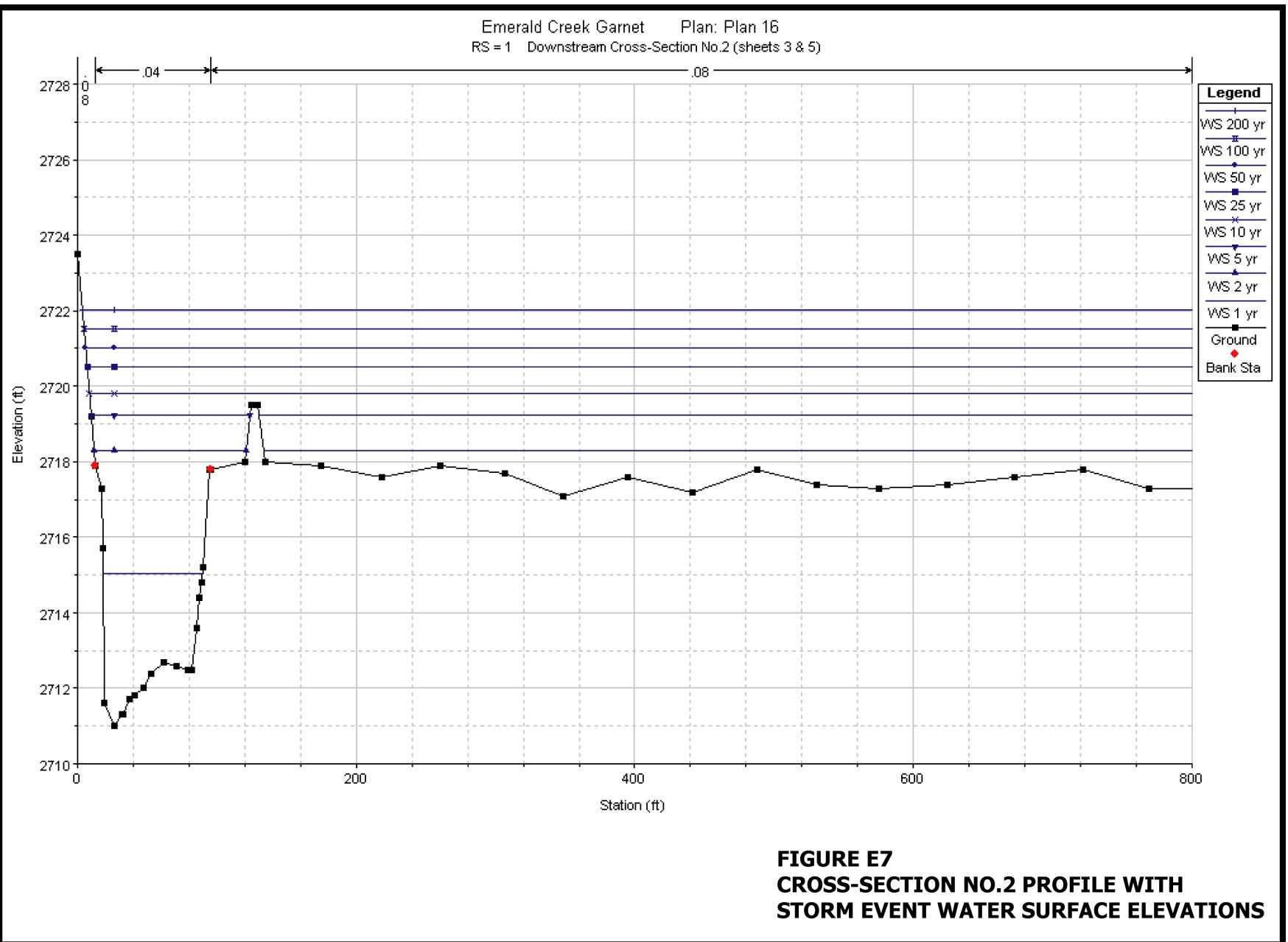


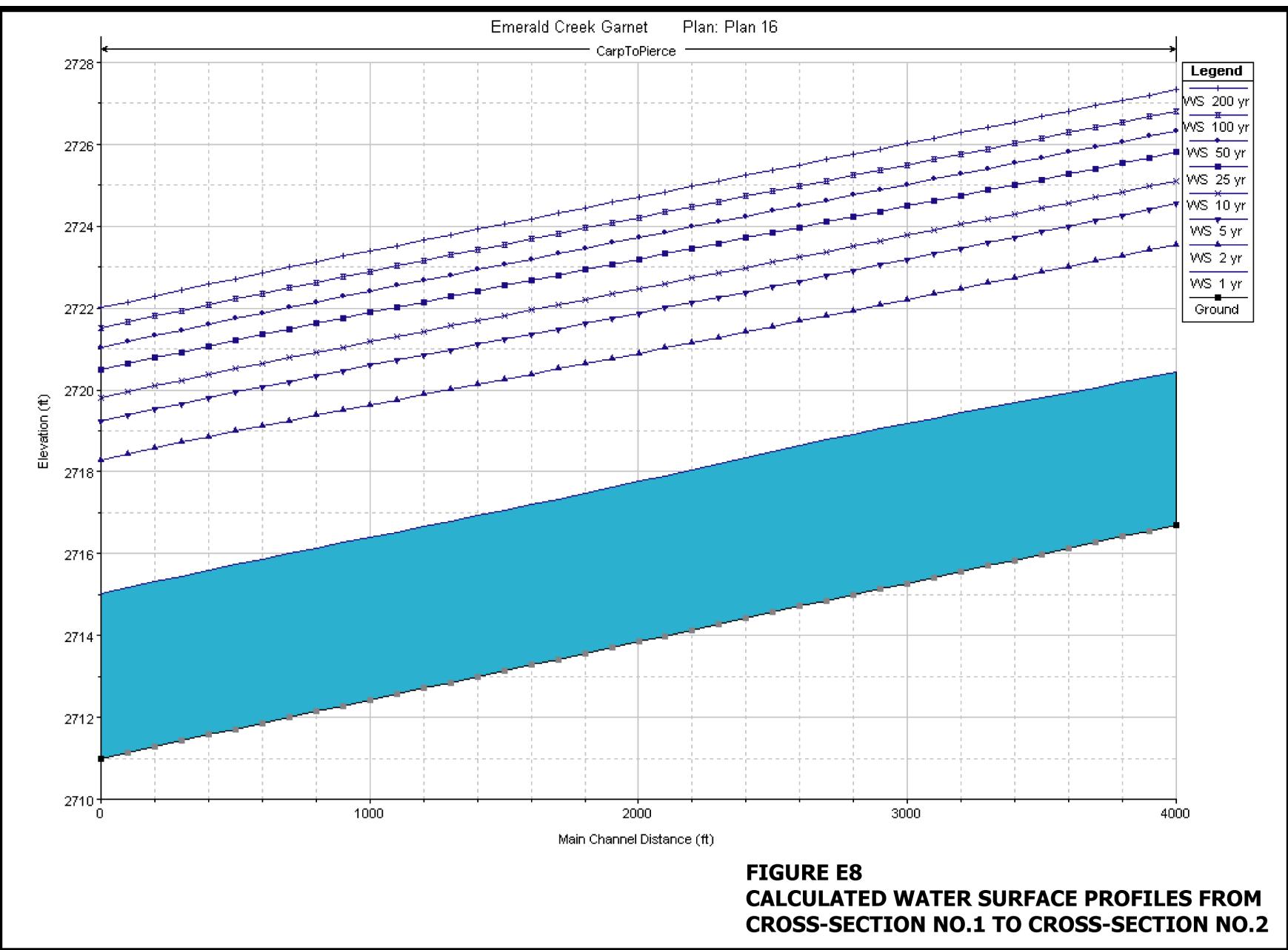




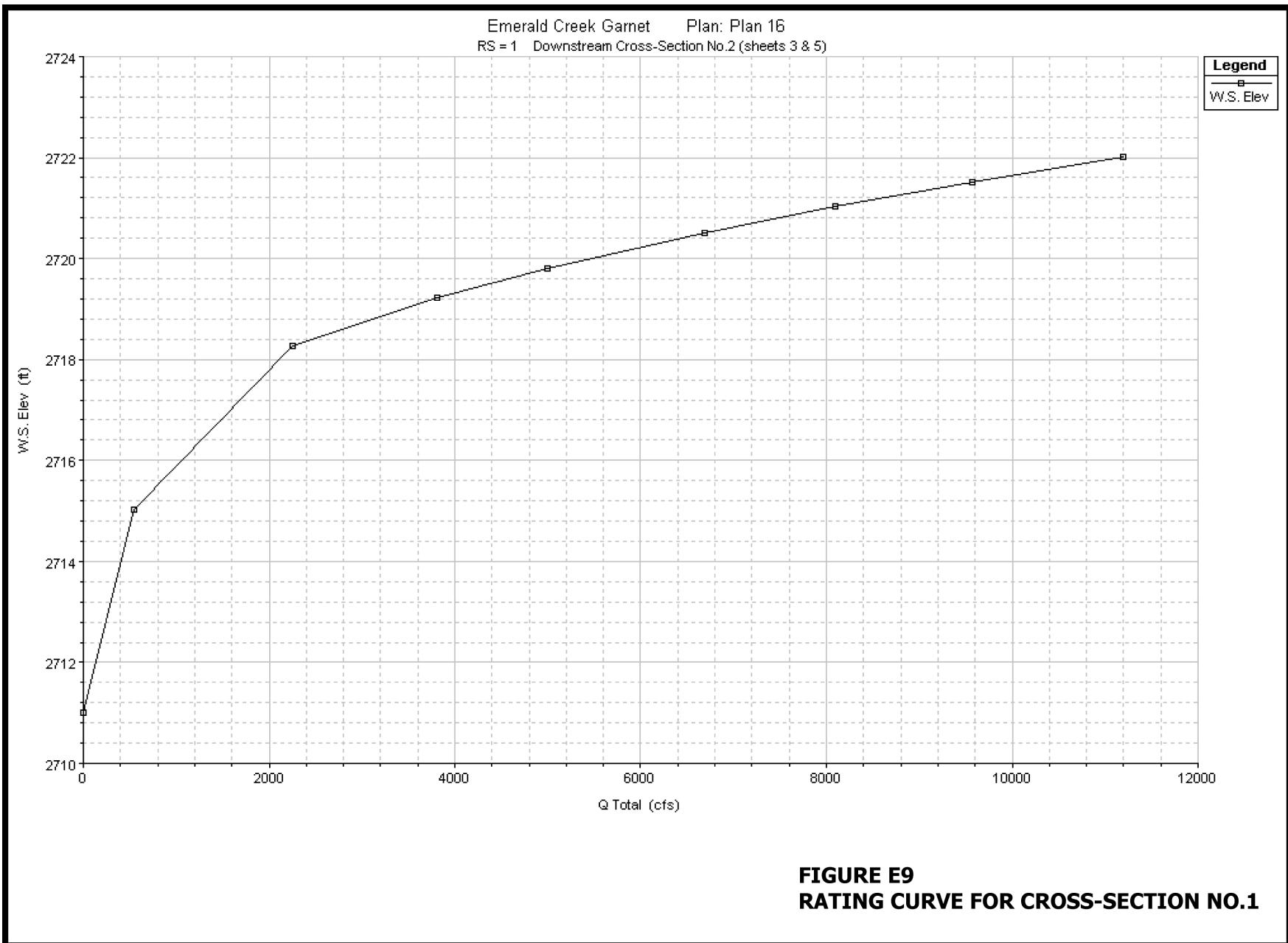








E-11



Emerald Creek Garnet Plan: Plan 16
RS = 10 Upstream Cross-Section No.1 (Sheets 2 & 4)

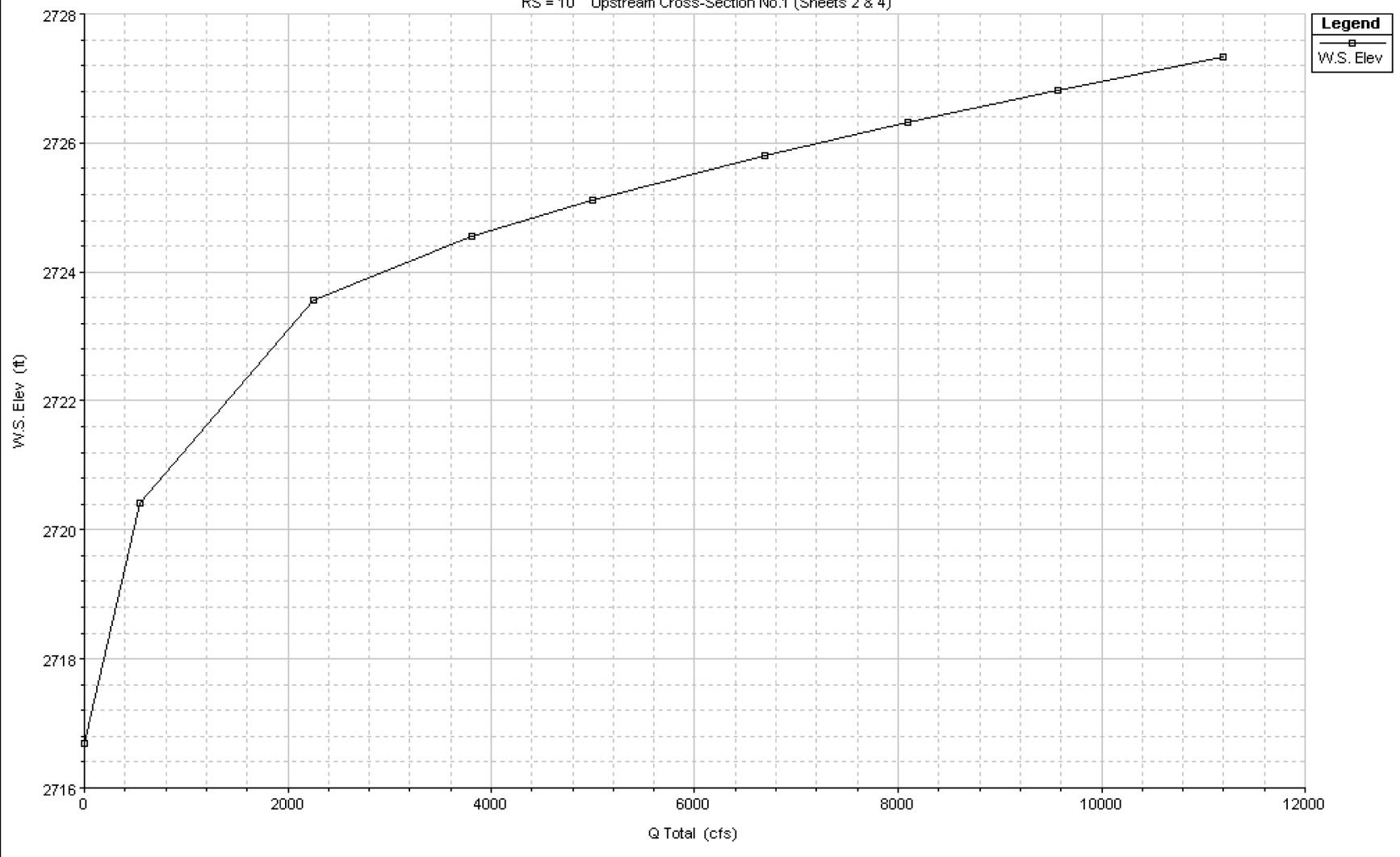


FIGURE E10
RATING CURVE FOR CROSS-SECTION NO.2

Lag Time and Time to Peak

In order to determine whether or not ECG's proposed shutdown criteria are adequate to protect the St. Maries River from a proposed upset condition during a flood, the time to peak for the watershed was calculated. Initially, the lag time, time between the centroid of rainfall excess and the peak of the unit hydrograph, was calculated. Secondly, the time to peak, or the time it takes for runoff from a watershed to reach its peak flow value, was calculated based on SCS methodology. The resulting time to peak was calculated to be 6.94 hours. Given that ECG will be tracking real-time storm and flood forecasting data during the winter and spring months (flood-prone season) ECG should have ample time to shutdown operations, mobilize and re-locate equipment outside of the floodplain when a flood event of any magnitude is forecasted, as ECG requires only four hours to enact these shutdown procedures.

$$T_{LAG} = \frac{L^{0.8} (S+1)^{0.7}}{1900 Y^{0.5}}$$

SOURCE:

2/26/02

NATIONAL ENGINEERING HANDBOOK, HYDROLOGY:
SECTION 4, AUGUST 1974

L = HYDRAULIC LENGTH OF WATERSHED, FT.

$S = \frac{1000}{CN} - 10$, POTENTIAL WATERSHED STORAGE, IN INCHES

Y = AVERAGE WATERSHED SLOPE, %

T_{LAG} = TIME FROM CENTER OF MASS RAINFALL TO PEAK OF HYDROGRAPH, HOURS

$$T_{PEAK} = T_{LAG} + D/2$$

D = DURATION OF RAINFALL EXCESS, HOURS

$$\text{ASSUME } D = T_{LAG}/2$$

* FOR ST. MARIES BASIN, ASSUME 50% TYPE B AND 50% TYPE C SOILS
AND 50% WOODS w/ FAIR COVER AND 50% WOODS / GRASS
COMPOSITE CN = $\cdot 5\left(\frac{60+73}{2}\right) + \cdot 5\left(\frac{65+76}{2}\right) = \underline{68.5} = CN$

$$L = 100,000 \text{ FT}$$

$$Y = 10\%$$

$$S = \frac{1000}{68.5} - 10 = 4.59 \text{ IN.}$$

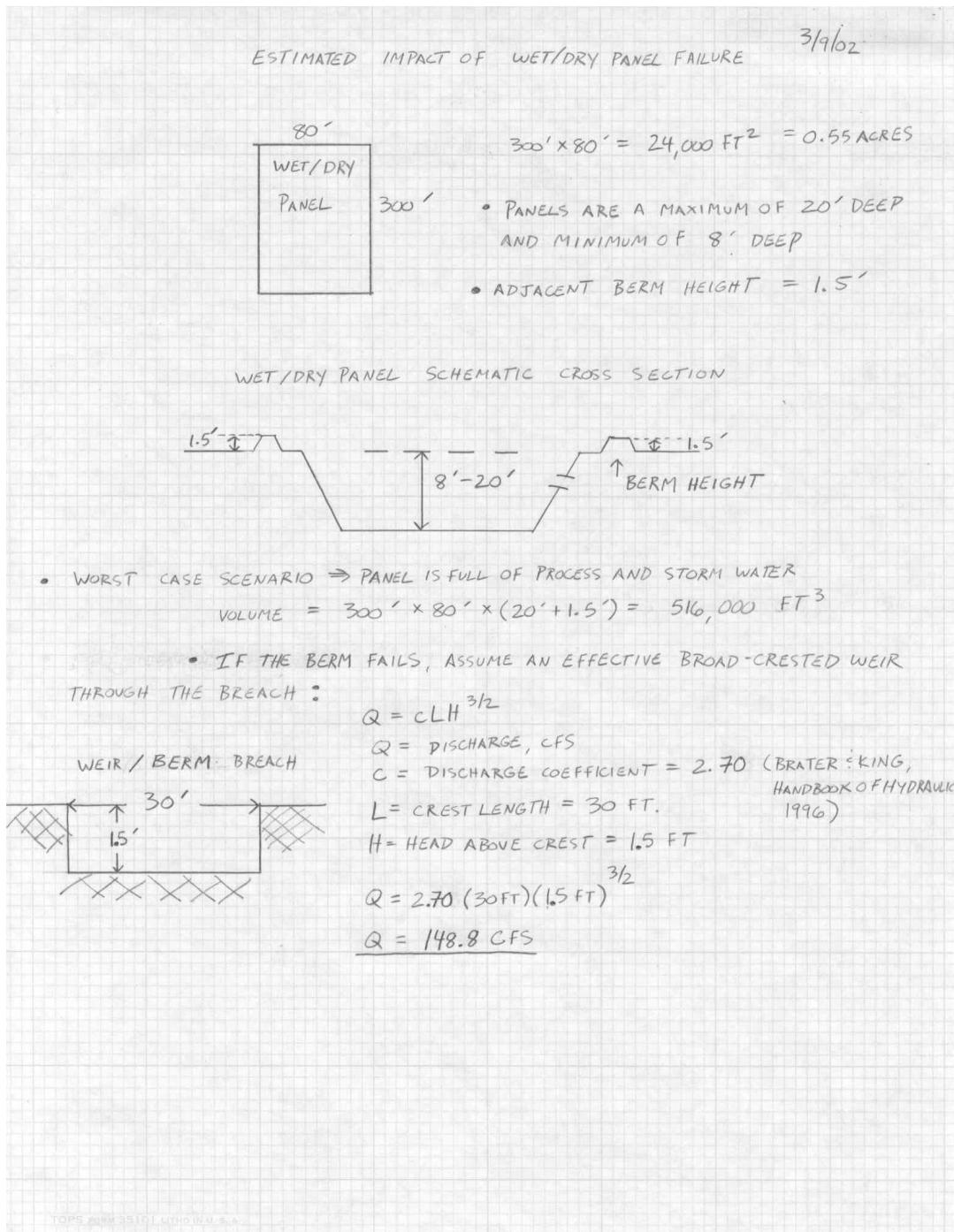
$$T_{LAG} = \frac{(100,000 \text{ FT})^{0.8} (4.59 \text{ IN.} + 1)^{0.7}}{1900 (10\%)^{0.5}} \Rightarrow \underline{T_{LAG} = 5.55 \text{ HRS.}}$$

$$T_{PEAK} = T_{LAG} + \frac{(T_{LAG}/2)}{2} = 5.55 \text{ HRS} + \frac{\left(\frac{5.55 \text{ HRS}}{2}\right)}{2} = \underline{6.94 \text{ HRS}}$$

$$\boxed{T_{PEAK} = 6.94 \text{ HRS}}$$

Estimated Impact of Panel Failure

Calculations were performed to determine the impact of a wet/dry mining panel berm failure on the receiving stream. Under worst-case conditions, a breach in the berm failure would cause the berm to behave as a broad-crested weir while discharging the impounded water to the St. Maries River. The resulting instantaneous discharge from the berm breach was calculated to be 150 cfs. During periods of baseflow or average annual monthly flows, such a breach would not cause downstream flooding. However, should such a breach occur during a 2-year flood or greater, downstream flooding could be exacerbated by such a failure if the peak flows occurred simultaneously.



Groundwater Hydrology

Groundwater Monitoring Well Hydraulic Gradient

In 1998, four groundwater-monitoring sites were established within the project area to measure typical groundwater fluctuations over a hydrologic cycle (Figure E11). Depth to shallow groundwater was measured weekly by ECG's Environmental Specialist during the period of December 1998 to October 2000 (Figure E12). The recorded values can be found on the following pages in Tables E5– E8. Several extraneous groundwater measurements were eliminated from the groundwater analysis. The seasonal groundwater levels fluctuated approximately 3ft in elevation. The hydraulic gradient of 0.0021 ft/ft was determined by taking the average change in groundwater surface elevation for the 1999 measurements and dividing by the horizontal distance between wells as shown below. Figure E13 illustrates the groundwater gradient for on a monthly basis and the average for the entire year.

$$\begin{aligned}\text{Groundwater Gradient} &= \Delta \text{Groundwater Surface Elevation} / \text{Distance Between Measurements} \\ &= (2722.31 - 2720.77) / (800 - 15) \\ &= \underline{\underline{0.00196 \text{ ft/ft}}}\end{aligned}$$

Figure E11: Groundwater Monitoring Well Locations

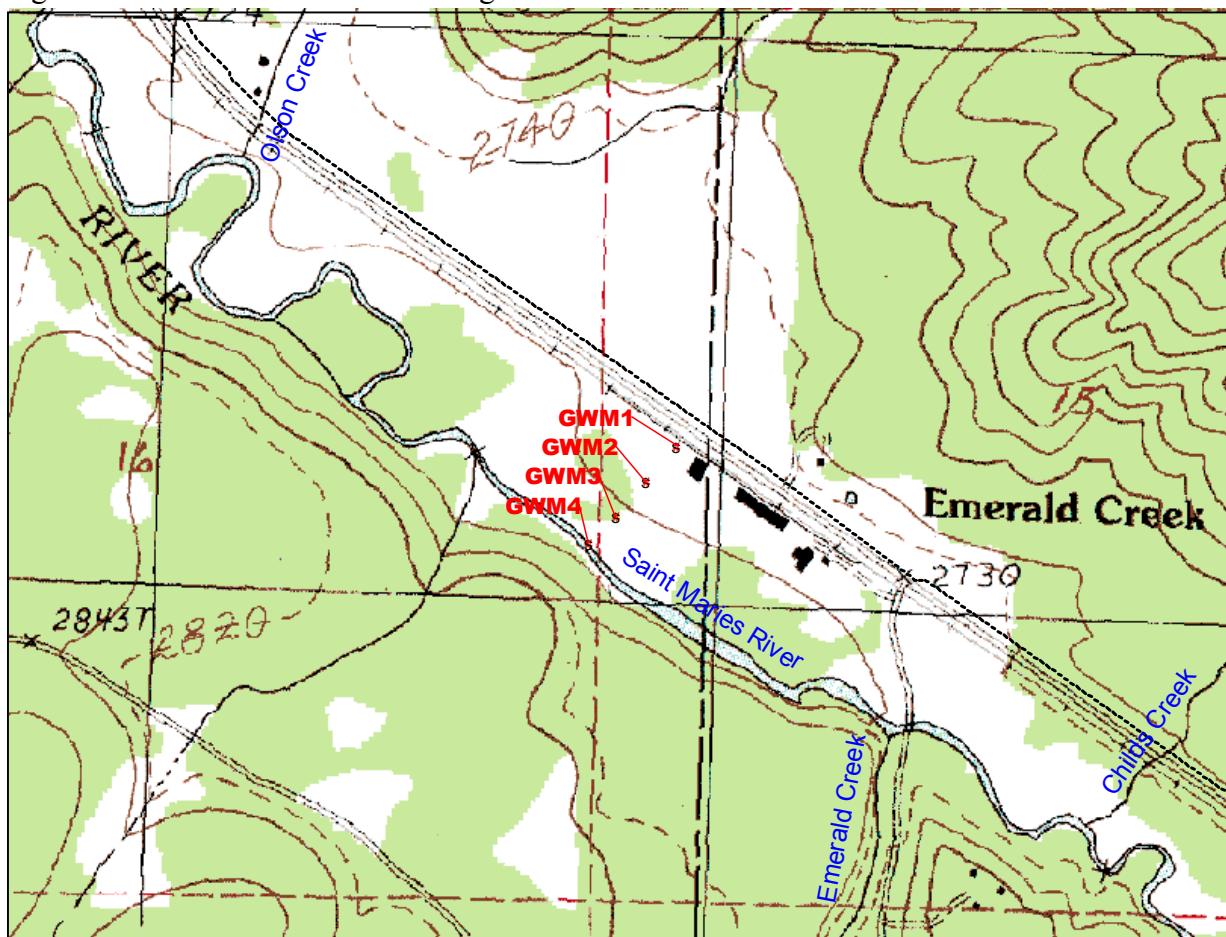


Figure E12: Groundwater Measurements from Dec 1998 – Oct. 2000

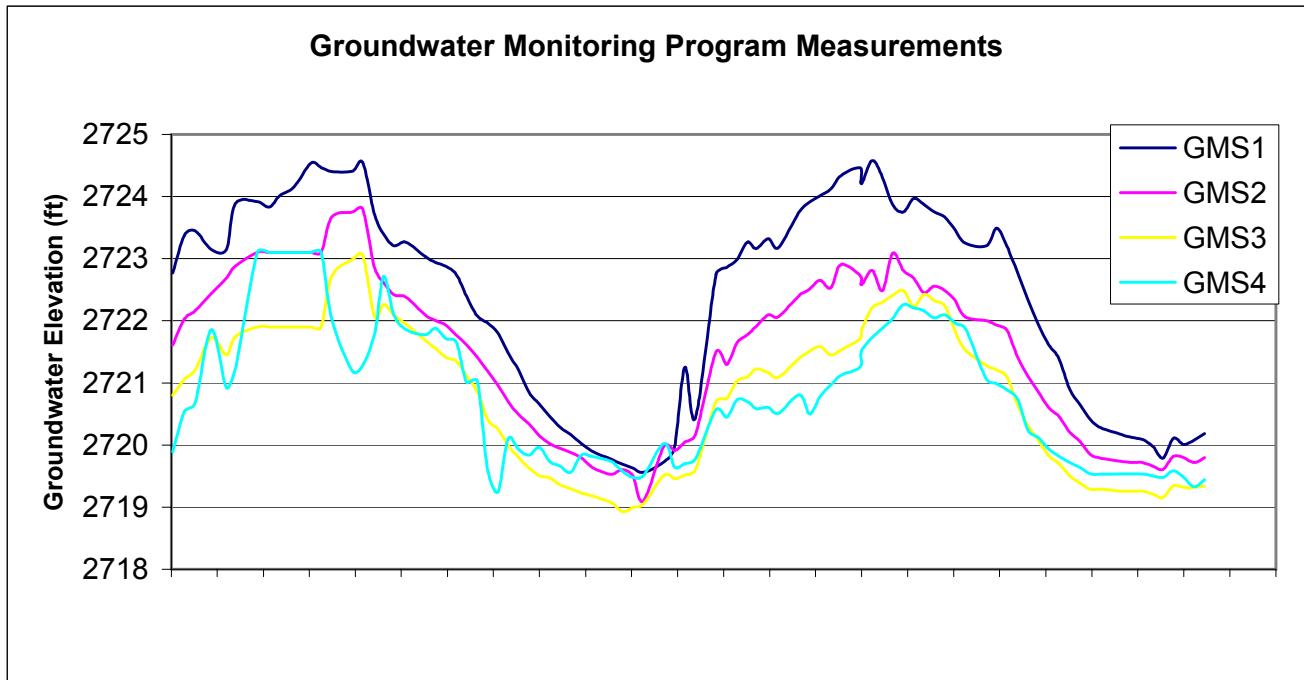
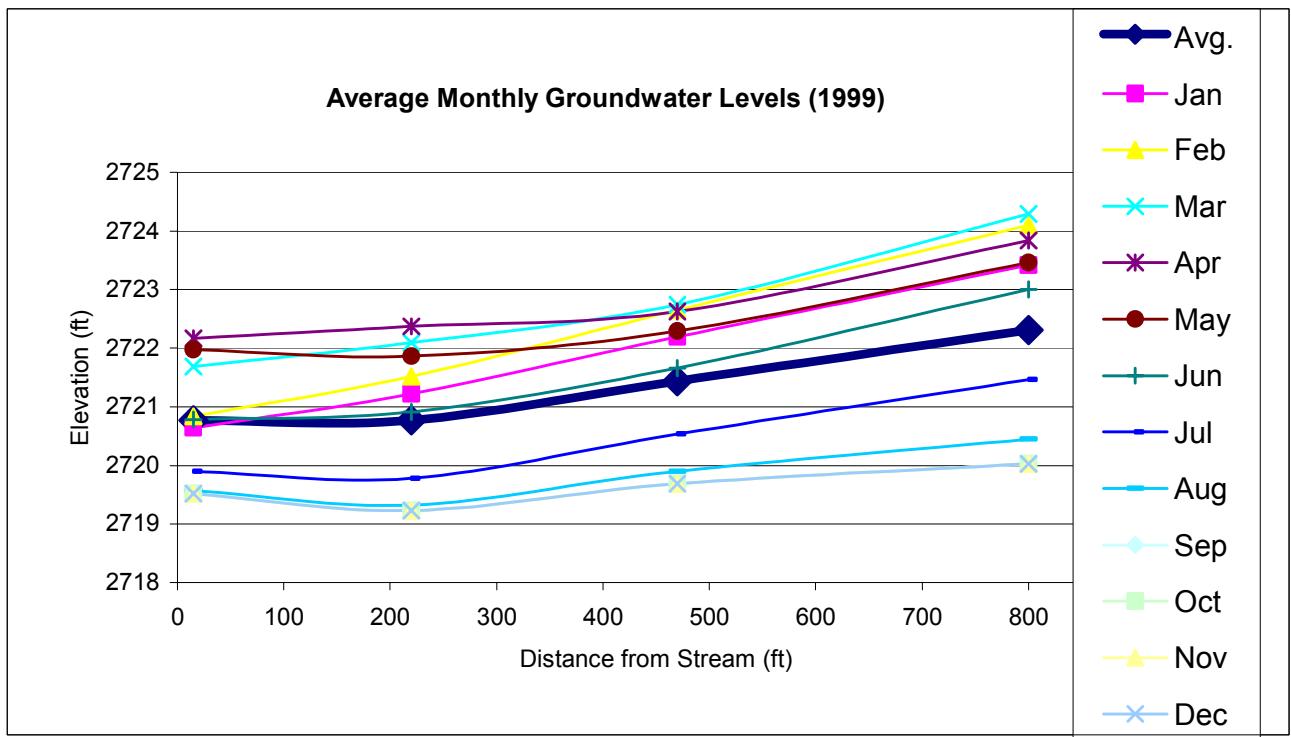


Figure E13: Groundwater Monitoring Well Data



2.2 Groundwater Velocity Calculations

It was initially thought that groundwater mounding, as a result of water-laden mining panels, would contribute to sediment loading within the St. Maries River as a result of particle "jetting". In contrast to that initial theory, the resulting groundwater velocity was calculated to be 2.19×10^{-5} ft/sec. Groundwater velocities of this magnitude cannot be expected to contribute to the transport of sediment through gravels at the site.

2/26/02

ST. MARIES

GROUNDWATER VELOCITY CALCULATIONS

DARCY'S LAW

$$V = \frac{Q}{A} = K \frac{\Delta h}{\Delta L}$$

K = hydraulic conductivity, cm/sec
 Δh = change in head between two points, ft
 ΔL = change in linear distance between two points, ft

- Assume $K = 10^{-3}$ cm/sec
 - FOR BASELINE CONDITION, ASSUME $\Delta h = 2$ ft and $\Delta L = 30$ ft
 - 30 ft. corresponds to mining panel setback from river

$$V_{gw\text{ baseline}} = \left(10^{-3} \text{ cm/sec}\right) \left(\frac{2 \text{ ft}}{(30 \text{ ft})}\right) \left(\frac{-\text{ft.}}{30.4 \text{ cm}}\right) = \underline{2.19 \times 10^{-6} \text{ ft/sec}}$$

Now, ASSUME MOUNDED WATER IN MINING PANEL AND DETERMINE INCREASE IN VELOCITY AS A RESULT OF INCREASED HEAD:
 WORST CASE WOULD BE 20 FT. MOUNDED WATER IN PANEL

$$V_{gw\text{ mounded}} = \left(10^{-3} \text{ cm/sec}\right) \left(\frac{20 \text{ ft}}{30 \text{ ft}}\right) \left(\frac{\text{ft}}{30.4 \text{ cm}}\right) = \underline{2.19 \times 10^{-5} \text{ ft/sec}}$$

CONCLUSION: THESE VELOCITIES ARE SO LOW (100,000 TIMES LESS THAN A TYPICAL STREAM FLOW) THAT GROUNDWATER MOUNDING, AS A RESULT OF MINING OPERATIONS, CANNOT BE AIDING TO THE TRANSPORT OF SEDIMENT THROUGH GRAVELS AT THE SITE. SEDIMENT TRANSPORT VELOCITIES SUCH AS THESE WOULD NOT BE DISCERNIBLE BY THE HUMAN EYE.

Table E5: Monitoring Well Data – GMS1 (Page 1 of 3)

Well Name:		GMS1	Surface Elevation (ft):	2726.7
Distance from OHW (ft):		800	Casing Stick Up (ft):	2.28
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
2-Dec-1998	Intermittent rains,40's	6.21	3.93	2722.77
10-Dec-1998	Overcast,30's	5.60	3.32	2723.38
17-Dec-1998	Clear, High,20's	5.53	3.25	2723.45
28-Dec-1998	Sleet W/ Rain,40's	5.83	3.55	2723.15
7-Jan-1999	Light Sprinkles,30's	5.83	3.55	2723.15
13-Jan-1999	Mild & Clear,40's	5.10	2.82	2723.88
22-Jan-1999	Intermittent Sleet,30's	4.41	2.13	2724.57
28-Jan-1999	Mild & Clear,40's	5.06	2.78	2723.92
5-Feb-1999	Sunny,50's	5.15	2.87	2723.83
12-Feb-1999	Overcast,40's	4.97	2.69	2724.01
22-Feb-1999	Overcast,30's	4.82	2.54	2724.16
5-Mar-1999	Overcast,1"Fresh Snow	4.44	2.16	2724.54
12-Mar-1999	Overcast,30's	4.51	2.23	2724.47
19-Mar-1999	Clear, High,40's	4.58	2.3	2724.4
26-Mar-1999	Clear ,30-40's	4.70	2.42	2724.28
2-Apr-1999	Clear,50's	4.57	2.29	2724.41
9-Apr-1999	Sunny,50's	4.43	2.15	2724.55
17-Apr-1999	Clear,50's	5.28	3.00	2723.7
23-Apr-1999	Clear,50's	5.58	3.30	2723.4
30-Apr-1999	Overcast, Light Sprinkles	5.77	3.49	2723.21
8-May-1999	Overcast, Snow 50's	5.71	3.43	2723.27
21-May-1999	Partly Cloudy,60's	5.94	3.66	2723.04
28-May-1999	Sunny,70's	6.04	3.76	2722.94
4-Jun-1999	Sunny,80's	6.10	3.82	2722.88
11-Jun-1999	Sunny,80's	6.23	3.95	2722.75
18-Jun-1999	Clear,80's	6.59	4.31	2722.39
25-Jun-1999	Heavy Rains,40-50's	6.90	4.62	2722.08
2-Jul-1999	Clear,80's	7.01	4.73	2721.97
9-Jul-1999	Clear,90's	7.17	4.89	2721.81
16-Jul-1999	Clear,80's	7.49	5.21	2721.49
23-Jul-1999	Clear,90's	7.78	5.5	2721.2
30-Jul-1999	Overcast,70-80's	8.13	5.85	2720.85
6-Aug-1999	Clear,90's	8.32	6.04	2720.66
13-Aug-1999	Clear,90's	8.52	6.24	2720.46
20-Aug-1999	Clear,90's	8.69	6.41	2720.29
27-Aug-1999	Clear,80's	8.81	6.53	2720.17
3-Sep-1999	Clear,80's	8.95	6.67	2720.03
10-Sep-1999	Clear,80's	9.07	6.79	2719.91
17-Sep-1999	Clear & Sunny,80's	9.15	6.87	2719.83
24-Sep-1999	Clear & Sunny,70's	9.21	6.93	2719.77
1-Oct-1999	Clear & Sunny,70's	9.29	7.01	2719.69
8-Oct-1999	Light Sprinkles,60's	9.35	7.07	2719.63
15-Oct-1999	Clear & Sunny,60's	9.42	7.14	2719.56

Table E5: Monitoring Well Data – GMS1 (Page 2 of 3)

Well Name:		GMS1	Surface Elevation (ft):	2726.7
Distance from OHW (ft):		800	Casing Stick Up (ft):	2.28
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
22-Oct-1999	Light Sprinkles,50's	9.53	7.25	2719.45
29-Oct-1999	Clear,50's	9.25	6.97	2719.73
5-Nov-1999	Overcast,30-40's	9.01	6.73	2719.97
12-Nov-1999	Clear,40's	7.73	5.45	2721.25
19-Nov-1999	Overcast,40's	8.54	6.26	2720.44
26-Nov-1999	Overcast, Heavy Rains	6.25	3.97	2728.98
3-Dec-1999	Partly Cloudy,30's	6.23	3.95	2722.75
10-Dec-1999	Snowing,30's	6.12	3.84	2722.86
17-Dec-1999	Overcast,20's	5.99	3.71	2722.99
24-Dec-1999	Overcast,30's	5.71	3.43	2723.27
30-Dec-1999	Overcast,30's	5.82	3.54	2723.16
7-Jan-2000	Snowing,20's	5.66	3.38	2723.32
14-Jan-2000	Raining Hard,30's	5.80	3.52	2723.18
21-Jan-2000	Snowing,20's	5.14	2.86	2728.98
28-Jan-2000	Snowing,20's	5.22	2.94	2723.76
4-Feb-2000	Cold & Clear,20's	5.07	2.79	2723.91
11-Feb-2000	Snowing,20's	4.97	2.69	2724.01
18-Feb-2000	Snowing,30's	4.86	2.58	2724.12
25-Feb-2000	Raining ,30's	4.64	2.36	2724.34
9-Mar-2000	Snowing,20's	4.51	2.23	2724.47
10-Mar-2000	Clear ,30's	4.77	2.49	2724.21
17-Mar-2000	Raining,30's	4.40	2.12	2724.58
24-Mar-2000	Snowing,30's	4.67	2.39	2724.31
31-Mar-2000	Sunny,30's	5.11	2.83	2723.87
7-Apr-2000	Sunny,30's	5.23	2.95	2723.75
14-Apr-2000	Raining,40's	5.01	2.73	2723.97
21-Apr-2000	Light Rain,40's	5.11	2.83	2723.87
28-Apr-2000	Clear ,50's	5.23	2.95	2723.75
5-May-2000	Light Rain,50's	5.31	3.03	2723.67
12-May-2000	Light Rain,50's	5.52	3.24	2723.46
19-May-2000	Sunny,70's	5.73	3.45	2723.25
26-May-2000	Sunny,70's	5.94	3.66	2728.98
2-Jun-2000	Clear & Sunny,60's	5.77	3.49	2723.21
9-Jun-2000	Clear & Sunny,60's	5.49	3.21	2723.49
16-Jun-2000	Clear & Sunny,50's	5.78	3.5	2723.2
23-Jun-2000	Clear & Sunny,70's	6.21	3.93	2722.77
30-Jun-2000	Clear & Sunny,80's	6.64	4.36	2722.34
7-Jul-2000	Clear & Sunny,70's	7.03	4.75	2721.95
14-Jul-2000	Clear & Sunny,80's	7.37	5.09	2721.61
21-Jul-2000	Clear & Sunny,80's	7.59	5.31	2721.39
28-Jul-2000	Clear & Sunny,80's	8.07	5.79	2720.91
4-Aug-2000	Clear & Sunny,90's	8.33	6.05	2720.65
11-Aug-2000	Clear & Sunny,80's	8.57	6.29	2720.41

Table E5: Monitoring Well Data – GMS1 (Page 2 of 3)

Well Name:		GMS1	Surface Elevation (ft):	2726.7
Distance from OHW (ft):		800	Casing Stick Up (ft):	2.28
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
18-Aug-2000	Clear & Sunny,80's	8.70	6.42	2720.28
25-Aug-2000	Clear & Sunny,80's	8.76	6.48	2728.98
1-Sep-2000	Clear & Sunny,100's	8.81	6.53	2720.17
8-Sep-2000	Clear & Sunny,80's	8.86	6.58	2720.12
15-Sep-2000	Clear & Sunny,80's	8.89	6.61	2720.09
22-Sep-2000	Clear & Sunny,80's	9.00	6.72	2719.98
29-Sep-2000	Overcast,60's	9.19	6.91	2719.79
6-Oct-2000	Clear & Sunny,50's	8.87	6.59	2720.11
13-Oct-2000	Heavy Rains,50's	8.97	6.69	2720.01
20-Oct-2000	Cloudy,40's	8.90	6.62	2720.08
27-Oct-2000	Overcast,40's	8.79	6.51	2720.19

Table E6: Monitoring Well Data - GMS2 (Page 1 of 3)

Well Name:		GMS2	Surface Elevation (ft):	2725.4
Distance from OHW (ft):		470	Casing Stick Up (ft):	2.02
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
2-Dec-1998	Intermittent, Rains 40's	5.81	3.79	2721.6
10-Dec-1998	Overcast,30's	5.39	3.37	2722.0
17-Dec-1998	Clear, High 20's	5.26	3.24	2722.2
28-Dec-1998	Sleet/Winds,40's	4.98	2.96	2722.4
7-Jan-1999	Light Sprinkles, High 30's	4.73	2.71	2722.7
13-Jan-1999	Mild,Clear,40's	4.54	2.52	2722.9
22-Jan-1999	Sleet ,	3.79	1.77	2723.6
28-Jan-1999	Mild-Clear,	4.32	2.30	2723.1
5-Mar-1999	Overcast,1"New Snow	3.53	1.51	2723.9
12-Mar-1999	Overcast,30's	3.69	1.67	2723.7
19-Mar-1999	Clear,40's	3.75	1.73	2723.7
26-Mar-1999	Clear,30's - 40's	3.50	1.48	2723.9
2-Apr-1999	Clear,50's	3.67	1.65	2723.8
9-Apr-1999	Sunny,50's	3.62	1.60	2723.8
17-Apr-1999	Clear,50's	4.58	2.56	2722.8
23-Apr-1999	Clear,50's	4.80	2.78	2722.6
30-Apr-1999	Light Rain,50's	5.00	2.98	2722.4
8-May-1999	Overcast/Snow,50's	5.04	3.02	2722.4
21-May-1999	Partly Cloudy,60's	5.32	3.30	2722.1
28-May-1999	Sunny,70's	5.41	3.39	2722.0
4-Jun-1999	Sunny,80's	5.49	3.47	2721.9
11-Jun-1999	Sunny,80's	5.65	3.63	2721.8
18-Jun-1999	Clear,80's	5.81	3.79	2721.6
25-Jun-1999	Heavy Rains,40's -50's	6.00	3.98	2721.4
2-Jul-1999	Clear,80's	6.23	4.21	2721.2
9-Jul-1999	Clear,90's	6.45	4.43	2721.0
16-Jul-1999	Clear,80's	6.71	4.69	2720.7
23-Jul-1999	Clear,90's	6.93	4.91	2720.5
30-Jul-1999	Overcast ,70 - 80's	7.08	5.06	2720.3
6-Aug-1999	Clear,90's	7.27	5.25	2720.2
13-Aug-1999	Clear,90's	7.40	5.38	2720.0
20-Aug-1999	Clear,90's	7.47	5.45	2720.0
27-Aug-1999	Clear,80's	7.54	5.52	2719.9
3-Sep-1999	Clear,80's	7.62	5.60	2719.8
10-Sep-1999	Clear,80's	7.77	5.75	2719.7
17-Sep-1999	Clear/Sunny,80's	7.85	5.83	2719.6
24-Sep-1999	Clear/Sunny,70's	7.89	5.87	2719.5
1-Oct-1999	Clear/Sunny,70's	7.82	5.80	2719.6
8-Oct-1999	Light Rain,60's	7.92	5.90	2719.5
15-Oct-1999	Clear/Sunny, low 60's	8.32	6.30	2719.1
22-Oct-1999	Light Rain,50's	8.96	6.94	2718.5
29-Oct-1999	Clear,50's	7.43	5.41	2720.0

Table E6: Monitoring Well Data - GMS2 (Page 2 of 3)

Well Name:		GMS2	Surface Elevation (ft):	2725.4
Distance from OHW (ft):		470	Casing Stick Up (ft):	2.02
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
5-Nov-1999	Overcast ,30 - 40's	7.51	5.49	2719.9
12-Nov-1999	Clear/Light Rain,40's	7.37	5.35	2720.1
19-Nov-1999	Overcast ,40's	7.25	5.23	2720.2
26-Nov-1999	Overcast ,40's	5.64	3.62	2721.8
3-Dec-1999	Partly Cloudy,30's	5.92	3.90	2721.5
10-Dec-1999	Snowing,30's	6.12	4.10	2721.3
17-Dec-1999	Overcast ,20's	5.77	3.75	2721.7
24-Dec-1999	Overcast ,30's	5.64	3.62	2721.8
30-Dec-1999	Overcast ,30's	5.51	3.49	2721.9
7-Jan-2000	Snowing,20's	5.32	3.30	2722.1
14-Jan-2000	Raining,30's	5.35	3.33	2722.1
21-Jan-2000	Snowing,20's	5.15	3.13	2722.3
28-Jan-2000	Snowing,20's	5.01	2.99	2722.4
4-Feb-2000	Cold & Clear,20's	4.91	2.89	2722.5
5-Feb-2000	Sunny,50's	5.70	3.68	2721.7
11-Feb-2000	Snowing,20's	4.77	2.75	2722.7
12-Feb-2000	Overcast,40's	4.48	2.46	2722.9
18-Feb-2000	Snowing,30's	4.89	2.87	2722.5
22-Feb-2000	Overcast,30's	4.57	2.55	2722.9
25-Feb-2000	Raining,30's	4.51	2.49	2722.9
3-Mar-2000	Snowing,20's	4.69	2.67	2722.7
10-Mar-2000	Clear, High 30's	4.84	2.82	2722.6
17-Mar-2000	Raining,30's	4.61	2.59	2722.8
24-Mar-2000	Snowing,30's	4.93	2.91	2722.5
31-Mar-2000	Sunny,50's	4.33	2.31	2723.1
2-Apr-2000	Sunny,50's	4.61	2.59	2722.8
14-Apr-2000	Raining,40's	4.73	2.71	2722.7
21-Apr-2000	Light Rain,40's	4.97	2.95	2722.5
28-Apr-2000	Clear,50's	4.86	2.84	2722.6
5-May-2000	Light Rain,50's	4.93	2.91	2722.5
12-May-2000	Light Rain,50's	5.09	3.07	2722.3
19-May-2000	Sunny,70's	5.36	3.34	2722.1
26-May-2000	Sunny,70's	5.50	3.48	2721.9
2-Jun-2000	Clear/Sunny,60's	5.42	3.40	2722.0
9-Jun-2000	Clear/Sunny,60's	5.49	3.47	2721.9
16-Jun-2000	Clear/Cold,50's	5.57	3.55	2721.9
23-Jun-2000	Clear/Sunny,70's	6.00	3.98	2721.4
30-Jun-2000	Clear/Sunny,80's	6.31	4.29	2721.1
7-Jul-2000	Clear/Sunny,70's	6.56	4.54	2720.9
14-Jul-2000	Clear & Sunny,80's	6.82	4.80	2720.6
21-Jul-2000	Clear & Sunny,80's	6.96	4.94	2720.5
28-Jul-2000	Clear & Sunny,80's	7.21	5.19	2720.2

Table E6: Monitoring Well Data - GMS2 (Page 3 of 3)

<i>Well Name:</i>		<i>GMS2</i>	Surface Elevation (ft):	2725.4
Distance from OHW (ft):		470	Casing Stick Up (ft):	2.02
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
4-Aug-2000	Clear & Sunny,90's	7.36	5.34	2720.1
11-Aug-2000	Clear & Sunny,80's	7.57	5.55	2719.9
18-Aug-2000	Clear & Sunny,80's	7.63	5.61	2719.8
25-Aug-2000	Clear & Sunny,80's	7.65	5.63	2719.8
1-Sep-2000	Clear & Sunny,100 Degrees	7.68	5.66	2719.7
8-Sep-2000	Clear & Sunny,90's	7.70	5.68	2719.7
15-Sep-2000	Clear & Sunny,80's	7.70	5.68	2719.7
22-Sep-2000	Clear & Sunny,80's	7.76	5.74	2719.7
29-Sep-2000	Overcast,60's	7.81	5.79	2719.6
6-Oct-2000	Clear & Sunny,50's	7.60	5.58	2719.8
13-Oct-2000	Heavy Rains,50's	7.62	5.60	2719.8
20-Oct-2000	Cloudy,40's	7.70	5.68	2719.7
27-Oct-2000	Light Showers, Overcast	7.62	5.60	2719.8

Table E7: Monitoring Well Data - GMS3 (Page 1 of 3)

Well Name:	GMS3	Surface Elevation (ft):	2723.4	
Distance from OHW (ft):	220	Casing Stick Up (ft):	3.12	
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
12/2/1998	Intermittent	5.72	2.60	2720.80
12/10/1998	Overcast	5.46	2.34	2721.06
12/17/1998	Clear	5.31	2.19	2721.21
12/28/1998	Sleet/Winds	4.79	1.67	2721.73
1/7/1999	Light Sprinkles	5.07	1.95	2721.45
1/13/1999	Mild, Clear	4.78	1.66	2721.74
1/22/1999	Sleet	4.11	0.99	2722.41
1/28/1999	Mild-Clear	4.62	1.50	2721.9
3/5/1999	Overcast	3.46	0.34	2723.06
3/12/1999	Overcast	3.73	0.61	2722.79
3/19/1999	Clear	3.80	0.68	2722.72
3/26/1999	Clear	3.24	0.12	2723.28
4/2/1999	Clear	3.53	0.41	2722.99
4/9/1999	Sunny	3.46	0.34	2723.06
4/17/1999	Clear	4.46	1.34	2722.06
4/23/1999	Clear	4.25	1.13	2722.27
4/30/1999	Light Rain	4.43	1.31	2722.09
5/8/1999	Overcast/Snow	4.57	1.45	2721.95
5/21/1999	Partly Cloudy	4.83	1.71	2721.69
5/28/1999	Sunny	4.96	1.84	2721.56
6/4/1999	Sunny	5.11	1.99	2721.41
6/11/1999	Sunny	5.17	2.05	2721.35
6/18/1999	Clear	5.41	2.29	2721.11
6/25/1999	Heavy Rains	5.66	2.54	2720.86
7/2/1999	Clear	6.11	2.99	2720.41
7/9/1999	Clear	6.26	3.14	2720.26
7/16/1999	Clear	6.52	3.40	2720
7/23/1999	Clear	6.72	3.60	2719.8
7/30/1999	Overcast	6.89	3.77	2719.63
8/6/1999	Clear	7.01	3.89	2719.51
8/13/1999	Clear	7.05	3.93	2719.47
8/20/1999	Clear	7.16	4.04	2719.36
8/27/1999	Clear	7.22	4.10	2719.3
9/3/1999	Clear	7.29	4.17	2719.23
9/10/1999	Clear	7.33	4.21	2719.19
9/17/1999	Clear/Sunny	7.39	4.27	2719.13
9/24/1999	Clear/Sunny	7.45	4.33	2719.07
10/1/1999	Clear/Sunny	7.59	4.47	2718.93
10/8/1999	Light Rain	7.52	4.40	2719
10/15/1999	Clear/Sunny	7.47	4.35	2719.05
10/22/1999	Light Rain	7.36	4.24	2719.16
10/29/1999	Clear	7.00	3.88	2719.52

Table E7: Monitoring Well Data - GMS3 (Page 2 of 3)

Well Name:		GMS3	Surface Elevation (ft):	2723.4
Distance from OHW (ft):		220	Casing Stick Up (ft):	3.12
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
11/5/1999	Overcast	7.06	3.94	2719.46
11/12/1999	Clear/Light Rain	7.00	3.88	2719.52
11/19/1999	Overcast	6.92	3.80	2719.6
11/26/1999	Overcast	5.07	1.95	2721.45
12/3/1999	Partly Cloudy	5.82	2.70	2720.7
12/10/1999	Snowing	5.77	2.65	2720.75
12/17/1999	Overcast	5.49	2.37	2721.03
12/24/1999	Overcast	5.42	2.30	2721.1
12/30/1999	Overcast	5.29	2.17	2721.23
1/7/2000	Snowing	5.35	2.23	2721.17
1/14/2000	Raining	5.43	2.31	2721.09
1/21/2000	Snowing	5.22	2.10	2721.3
1/28/2000	Snowing	5.12	2.00	2721.4
2/4/2000	Cold & Clear	5.01	1.89	2721.51
2/5/2000	Sunny	4.91	1.79	2721.61
2/11/2000	Snowing	4.93	1.81	2721.59
2/12/2000	Overcast	4.80	1.68	2721.72
2/18/2000	Snowing	5.07	1.95	2721.45
2/22/2000	Overcast	4.92	1.80	2721.6
2/25/2000	Raining	4.99	1.87	2721.53
3/3/2000	Snowing	4.81	1.69	2721.71
3/10/2000	Clear	4.67	1.55	2721.85
3/17/2000	Raining	4.31	1.19	2722.21
3/24/2000	Snowing	4.22	1.10	2722.3
3/31/2000	Sunny	4.11	0.99	2722.41
4/2/2000	Sunny	4.03	0.91	2722.49
4/14/2000	Raining	4.29	1.17	2722.23
4/21/2000	Light Rain	4.09	0.97	2722.43
4/28/2000	Clear	4.19	1.07	2722.33
5/5/2000	Light Rain	4.28	1.16	2722.24
5/12/2000	Light Rain	4.69	1.57	2721.83
5/19/2000	Sunny	4.99	1.87	2721.53
5/26/2000	Sunny	5.22	2.10	2721.3
6/2/2000	Clear/Sunny	5.24	2.12	2721.28
6/9/2000	Clear/Sunny	5.31	2.19	2721.21
6/16/2000	Clear/Cold	5.42	2.30	2721.1
6/23/2000	Clear/Sunny	5.87	2.75	2720.65
6/30/2000	Clear/Sunny	6.21	3.09	2720.31
7/7/2000	Clear/Sunny	6.44	3.32	2720.08
7/14/2000	Clear & Sunny	6.69	3.57	2719.83
7/21/2000	Clear & Sunny	6.82	3.70	2719.7
7/28/2000	Clear & Sunny	7.01	3.89	2719.51

Table E7: Monitoring Well Data - GMS3 (Page 3 of 3)

Well Name:	GMS3	Surface Elevation (ft):	2723.4	
Distance from OHW (ft):	220	Casing Stick Up (ft):	3.12	
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
8/4/2000	Clear & Sunny	7.13	4.01	2719.39
8/11/2000	Clear & Sunny	7.23	4.11	2719.29
8/18/2000	Clear & Sunny	7.23	4.11	2719.29
8/25/2000	Clear & Sunny	7.24	4.12	2719.28
9/1/2000	Clear & Sunny	7.26	4.14	2719.26
9/8/2000	Clear & Sunny	7.26	4.14	2719.26
9/15/2000	Clear & Sunny	7.26	4.14	2719.26
9/22/2000	Clear & Sunny	7.31	4.19	2719.21
9/29/2000	Overcast	7.36	4.24	2719.16
10/6/2000	Clear & Sunny	7.17	4.05	2719.35
10/13/2000	Heavy Rains	7.20	4.08	2719.32
10/20/2000	Cloudy	7.20	4.08	2719.32
10/27/2000	Light Showers	7.18	4.06	2719.34

Table E8: Monitoring Well Data - GMS4 (Page 1 of 3)

Well Name:		GMS4	Surface Elevation (ft):	2723.5
Distance from OHW (ft):		15	Casing Stick Up (ft):	2.65
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
12/2/1998	Intermittent, Rains 40's	5.81	3.61	2719.89
12/10/1998	Overcast,30's	5.61	2.96	2720.54
12/17/1998	Clear, High 20's	5.47	2.82	2720.68
12/28/1998	Sleet/Winds,40's	4.29	1.64	2721.86
1/7/1999	Light Sprinkles, High 30's	5.23	2.58	2720.92
1/13/1999	Mild,Clear,40's	4.94	2.29	2721.21
1/22/1999	Sleet ,	4.45	1.80	2721.7
1/28/1999	Mild-Clear,	5.13	2.30	2723.1
3/5/1999	Overcast,1"New Snow	4.00	1.35	2722.15
3/12/1999	Overcast,30's	4.07	1.42	2722.08
3/19/1999	Clear,40's	4.12	1.47	2722.03
3/26/1999	Clear,30's - 40's	river flooding	river flooding	na
4/2/1999	Clear,50's	4.96	2.31	2721.19
4/9/1999	Sunny,50's	4.87	2.22	2721.28
4/17/1999	Clear,50's	4.35	1.70	2721.8
4/23/1999	Clear,50's	3.44	0.79	2722.71
4/30/1999	Light Rain,50's	4.05	1.40	2722.1
5/8/1999	Overcast/Snow,50's	4.29	1.64	2721.86
5/21/1999	Partly Cloudy,60's	4.37	1.72	2721.78
5/28/1999	Sunny,70's	4.27	1.62	2721.88
6/4/1999	Sunny,80's	4.44	1.79	2721.71
6/11/1999	Sunny,80's	4.49	1.84	2721.66
6/18/1999	Clear,80's	5.14	2.49	2721.01
6/25/1999	Heavy Rains,40's -50's	5.12	2.47	2721.03
7/2/1999	Clear,80's	6.55	3.90	2719.6
7/9/1999	Clear,90's	6.91	4.26	2719.24
7/16/1999	Clear,80's	6.05	3.40	2720.1
7/23/1999	Clear,90's	6.22	3.57	2719.93
7/30/1999	Overcast ,70 - 80's	6.31	3.66	2719.84
8/6/1999	Clear,90's	6.19	3.54	2719.96
8/13/1999	Clear,90's	6.42	3.77	2719.73
8/20/1999	Clear,90's	6.49	3.84	2719.66
8/27/1999	Clear,80's	6.59	3.94	2719.56
9/3/1999	Clear,80's	6.31	3.66	2719.84
9/10/1999	Clear,80's	6.33	3.68	2719.82
9/17/1999	Clear/Sunny,80's	6.37	3.72	2719.78
9/24/1999	Clear/Sunny,70's	6.42	3.77	2719.73
10/1/1999	Clear/Sunny,70's	6.58	3.93	2719.57
10/8/1999	Light Rain,60's	6.67	4.02	2719.48
10/15/1999	Clear/Sunny, low 60's	6.64	3.99	2719.51
10/22/1999	Light Rain,50's	6.65	4.00	2719.5
10/29/1999	Clear,50's	6.12	3.47	2720.03

Table E8: Monitoring Well Data - GMS4 (Page 2 of 3)

<i>Well Name:</i>	<i>GMS4</i>	Surface Elevation (ft):	2723.5	
Distance from OHW (ft):	15	Casing Stick Up (ft):	2.65	
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
11/5/1999	Overcast ,30 - 40's	6.50	3.85	2719.65
11/12/1999	Clear/Light Rain,40's	6.45	3.80	2719.7
11/19/1999	Overcast ,40's	6.37	3.72	2719.78
11/26/1999	Overcast ,40's	5.28	2.63	2720.87
12/3/1999	Partly Cloudy,30's	5.58	2.93	2720.57
12/10/1999	Snowing,30's	5.70	3.05	2720.45
12/17/1999	Overcast ,20's	5.42	2.77	2720.73
12/24/1999	Overcast ,30's	5.45	2.80	2720.7
12/30/1999	Overcast ,30's	5.56	2.91	2720.59
1/7/2000	Snowing,20's	5.54	2.89	2720.61
1/14/2000	Raining,30's	5.64	2.99	2720.51
1/21/2000	Snowing,20's	5.45	2.80	2720.7
1/28/2000	Snowing,20's	5.34	2.69	2720.81
2/4/2000	Cold & Clear,20's	5.65	3.00	2720.5
2/5/2000	Sunny,50's	5.35	2.70	2720.8
2/11/2000	Snowing,20's	5.37	2.72	2720.78
2/12/2000	Overcast,40's	5.20	2.55	2720.95
2/18/2000	Snowing,30's	5.19	2.54	2720.96
2/22/2000	Overcast,30's	5.33	2.68	2720.82
2/25/2000	Raining,30's	5.03	2.38	2721.12
3/3/2000	Snowing,20's	4.89	2.24	2721.26
3/10/2000	Clear, High 30's	4.63	1.98	2721.52
3/17/2000	Raining,30's	4.42	1.77	2721.73
3/24/2000	Snowing,30's	4.27	1.62	2721.88
3/31/2000	Sunny,50's	4.11	1.46	2722.04
4/2/2000	Sunny,50's	3.89	1.24	2722.26
4/14/2000	Raining,40's	3.94	1.29	2722.21
4/21/2000	Light Rain,40's	3.99	1.34	2722.16
4/28/2000	Clear,50's	4.10	1.45	2722.05
5/5/2000	Light Rain,50's	4.05	1.40	2722.1
5/12/2000	Light Rain,50's	4.19	1.54	2721.96
5/19/2000	Sunny,70's	4.28	1.63	2721.87
5/26/2000	Sunny,70's	river flooding	river flooding	na
6/2/2000	Clear/Sunny,60's	5.09	2.44	2721.06
6/9/2000	Clear/Sunny,60's	5.16	2.51	2720.99
6/16/2000	Clear/Cold,50's	5.26	2.61	2720.89
6/23/2000	Clear/Sunny,70's	5.41	2.76	2720.74
6/30/2000	Clear/Sunny,80's	5.91	3.26	2720.24
7/7/2000	Clear/Sunny,70's	6.03	3.38	2720.12
7/14/2000	Clear & Sunny,80's	6.21	3.56	2719.94
7/21/2000	Clear & Sunny,80's	6.33	3.68	2719.82
7/28/2000	Clear & Sunny,80's	6.43	3.78	2719.72

Table E8: Monitoring Well Data - GMS4 (Page 3 of 3)

Well Name:		GMS4	Surface Elevation (ft):	2723.5
Distance from OHW (ft):		15	Casing Stick Up (ft):	2.65
Date	Weather Conditions	Measured Depth to Water from Top (ft)	Depth to Water Below Ground Surface (ft)	Ground Water Elevation (ft)
8/4/2000	Clear & Sunny,90's	6.51	3.86	2719.64
8/11/2000	Clear & Sunny,80's	6.61	3.96	2719.54
8/18/2000	Clear & Sunny,80's	6.62	3.97	2719.53
8/25/2000	Clear & Sunny,80's	6.64	3.99	2719.51
9/1/2000	Clear & Sunny,100 Degrees	6.61	3.96	2719.54
9/8/2000	Clear & Sunny,90's	6.61	3.96	2719.54
9/15/2000	Clear & Sunny,80's	6.61	3.96	2719.54
9/22/2000	Clear & Sunny,80's	6.64	3.99	2719.51
9/29/2000	Overcast,60's	6.67	4.02	2719.48
10/6/2000	Clear & Sunny,50's	6.56	3.91	2719.59
10/13/2000	Heavy Rains,50's	6.67	4.02	2719.48
10/20/2000	Cloudy,40's	6.82	4.17	2719.33
10/27/2000	Light Showers, Overcast	6.71	4.06	2719.44